The Impact of Fluctuation of Iron Ore Resource Imports on China's Macro-economy : Based on the CGE Model Analysis

Chen, Shuai
Graduate School of Economics, Kyushu University

https://doi.org/10.15017/19921

出版情報：経済論究. 140, pp.73-99, 2011-07. 九州大学大学院経済学会
バージョン：
権利関係：

The Impact of Fluctuation of Iron Ore Resource Imports on China's Macro-economy: Based on the CGE Model Analysis

Shuai Chen†

Index

1. Literature Review

Recently, China has consumed the largest amount of iron ore resources among all the countries of the world, however, the homemade iron reserves and qualities are relatively low. It has to import great a lot of iron ore abroad every year to satisfy the demand from domestic flourish steel, metallurgy and other industries. As a result, China has also become the largest importer of iron ore in the world. Meanwhile, the foreign dependence on iron ore is also quickly increasing, now more than 50%[1]. High foreign dependence brings much adverse influence on macro-economies and industries since international iron prices frequently fluctuate with large extent. This issue is becoming worse for China along with much failure in the international negotiations of iron ore prices, and has attracted much attention today. Based on this, this paper makes use of computable general equilibrium (CGE) model to study the impact of imports of iron ore resources on macro-economy, mainly simulating the fluctuations of import price and tariff rate

† Ph.D. Program 2nd Year, Graduate School of Economics, Kyushu University, Japan; E-mail: chenshuai@en.kyushu-u.ac.jp; I am grateful to Shanghai University of Finance and Economics for providing large datesets.

1) The website of the central government of the People's Republic of China: http://www.gov.cn/jrzg/2007-02/02/content_516243.htm.

of iron ore respectively, summarizing main points, and making policy recommendations.

1.1 Problem Analysis and Solutions

There have been many important researches to review this problem dialectically and seek solutions in the qualitative analysis. Bruce (1994) fully discussed opportunities and challenges of Canada's iron ore to conclude that iron ore export strategy makes Canada earn much profit, but it has to deal with the problem of lower qualities of domestic iron ore[2]. Schmitz (2005) analyzed a series of measures taken by the United States to overcome the crisis in the 1980s to ease the competition from Brazil's iron ore mining, and ultimately its labor productivity and utilization of natural resources and funding have been greatly improved[3]. Many Chinese scholars have also great concern about the issue. Liu (1996) analyzed the situation of China's steel industry, mainly from the perspective of domestic iron ore production, supply and demand, and proposed import strategy of iron ore in detail[4]. Chen (2003) considered it necessary to import lots of iron resources for China. But in reality, since companies unilaterally pursuit comparative advantage and neglect national natural resource policies, it results in import "trap" for mineral resources which actually reduce enterprises' profits in large[5]. Chen (2007) elaborated on China's strategic planning and rational distribution of iron ore imports, and then summarized and evaluated three ways of iron imports: long-term contract, spot transactions and foreign investment on mineral resources. He emphasized on foreign investment on mineral resources which was a global mineral strategy to ensure economy's safety and stability[6]. From current papers and literatures, many Chinese scholars (Duan, 2000; Xue, 2001; Yu, 2003; Wu, 2004, etc.) analyzed problems of China's iron ore import and considered that the limitations are mainly from export countries, price negotiations, transportation and companies themselves, and put forward some solutions.

Scholars had done much quantitative research at the same time. Totally speaking, most of these studies only considered several relative factors of this problem and ignored interactions and complexity of the economic system. Tchaetal (1999) made use of time-series data from 1973 to 1996 to analyze the situation that China had to import large amount of iron ore from Australia every year. He included variables like trade volume, GDP growth rate and government policies, and showed that China's imports from Australia and steel production had positive correlations

2) Bruce Boyd, 1994. Iron ore. *Canadian Minerals Yearbook*, 1994.
3) Schmitz and James, 2005. What Determines Productivity ? Lessons from the Dramatic Recovery of the U.S. and Canadian Iron Ore Industries Following Their Early 1980s Crisis. *Federal Reserve Bank of Minneapolis Research Department Staff Report 286*.
4) Liu, Q., 1996. Study on China's Steel Industries and Import Strategies of Iron Ore. *Foreign Metal and Mine (China)*, 9: 1-6.
5) Chen, J., 2003. Mineral Resources' Import Traps and Countermeasures. *Resource Development and Market (China)*, 19 (4): 241-242.
6) Chen, X., 2007. Strategies and Distributions of China's Imports of Iron Ore Resources. *Metallurgy Management (China)*, 1: 11-16.

with China's policies after the Great Cultural Revolution. Moreover, the increase of relative price of Australian mining and labor disputes reduced its import demand. Kirk (2004) analyzed the equilibrium status of the world's iron ore market in accordance that China had become the largest iron ore consumption country: from import price, Australian mines had more advantages than Brazil in freight, therefore, were easy to be accepted in real trade. But according to the principle of diversification of import strategies for China, other export countries such as India and South Africa should also be taken into considerations. Hu (2006) constructed an import optimization model to describe the decision-making optimization on iron ore imports for China. The results showed that we need to import a lot of iron resources from some certain countries, but they had limited capacity for long-term supply, while some small countries with little amount of exports may theoretically supply iron ore resources within a relative long-term period[7]. Li (2008) made data analysis to obtain that China had relied on iron ore imports very heavily, but serious problems existed: centralized iron ore sources, oligopoly of global provider, and increasing steel-making costs caused by high freight costs. She advocated strongly for diversified iron ore import sources, large scale foreign investment on mining, and technology innovation to reduce energy consumption[8].

1.2 Studies on the CGE Model

From surveying recent researches, the CGE (computable general equilibrium) model is mainly applied to analyze the problems of oil, coal and other common mineral resources. But iron ore resources are not given enough concern, even existed, the CGE model is only for simple reference and application.

Hoffman and Jorgesen (1977) established the link between energy system optimization model BESOM and the CGE model. Richard, Mun and Dale (1999) decomposed factors of input-output table of China from 1987 to 1992 and concluded that technical factor was the main reason of increasing energy efficiency, and structural adjustment was the secondary reason. Bhattacharyya (1996), Devarajan and Robinson (2002), and Bohringer and Losche (2006) summarized the roles of CGE model in the field of energy and climate policy from the perspective of technology and application, and discussed its future trends.

Chinese scholars also completed some studies using CGE model. Aiming at the frequently rising international oil prices, Wu (2005) constructed a CGE model to simulate the influence of

7) Hu, X. and J. Chen, 2006. Study on the Regional Choice and Decision-making Optimization in Utilizing Foreign Iron Ore Resources. *Metal and Mining (China)*, 2: 106-112.
8) Li, H., 2008. The Analysis of Situations of China's Iron Ore Imports. *North Economics and Business (China)*, 4: 51-52.
9) Wu, j., Z. Wang and B. Wu, 2005. The Shock of Rising Oil Price on China's Economy: The CGE Model Analysis. *Journal of China Agriculture University (Social Science Version)*, 2: 69-75.

GDP, price index and various commodity prices when energy price increased[9]. Wang (2006) constructed Shanghai's computable general equilibrium model based on data of input-output table 2002 of Shanghai, and showed that the energy tax on coal effectively substituted energy with labor[10]. Cai (2007) extended China's CGE model (called MCHUGE model), built substituted sectors of energy and energy intensity indicators, and incorporated them into structures of the MCHUGE model. And then he simulated the influence of technology progress, energy tax and energy price on energy intensity and economic growth[11]. Hu etc. (2008) also used MCHUGE model to analyze energy prices in detail. He transformed domestic consumptions of crude oil, coal, natural gas, and non-coal electricity into indicators of standard coal in accordance with standard coal coefficients, and then divided them by GDP to obtain indicators for energy intensity. The results showed that increased energy prices could significantly reduced China's energy intensity in short and long terms, meanwhile brought great negative impact on macro-economy which reduced GDP in short and long terms by restraining demand of exports and investment[12]. Deng etc. (2008) made use of the input-output table 2002 of Beijing and GEMPACK package to simulate water resource policies of Beijing, by constructing corresponding input-output table with 42 × 53 multi-sectors and CGE model of single water and waste water industries based on the general equilibrium theory[13].

Summarizing all the researches above, we can find that researches on the impact of iron ore resources on China's macro-economy can be classified into two types: qualitative research and quantitative research. Most of quantitative researches only check some hypotheses about the role of import and export in economic growth. The researches using the method of CGE are relatively little, and that there is no strict logical standard in construction of econometric models. Furthermore, according to existing literatures, the researches on the issue of China's iron ore are rather little, and most of them only focus on oil, coal and other common mineral resources.

2 . The CGE Model of China's Macro-economy Containing Import of Iron Ore Resources

Based on previous researches, this paper takes Devarajan, Lewis and Robinson's (1990) "1-2-3"

10) Wang, D., 2006. The Empirical Research on the Effect of Labor Substitution of Energy Tax: Based on Computation of CGE Model of Shanghai's Air Pollution in 2002. *Journal of Finance and Economics (China)*, 2: 98-105.
11) Cai, W., 2007. Research on the Energy Saving Policy Based on the CGE Model. Master's Degree Thesis for Hunan University (China).
12) Hu, Z., W. Cai and H. Chen, 2008. The CGE Study of the Impact of Energy Prices on Energy Intensity and Economic Growth. *Theory and Practice of Finance and Economics (China)*, 152: 91-95.
13) Deng, Q., 2008. The CGE Model of Water Resource Policy and Its Applications in Beijing. *Geography Development (China)*, 3: 141-151.

model[14] as theoretical basis, establishes CGE model of China's macro-economy containing import of iron ore resources, and makes simulation analysis. "1-2-3" model is a CGE model of open economy with one country, two production sectors (domestic-selling sector and export sector), and three goods (export goods, import goods and domestic goods). Here, export goods refers to homemade iron ore exported to foreign markets; import goods refers to domestically consumed iron ore imported from foreign markets; domestic goods are defined as homemade iron ore only sold in domestic market.

2.1 Basic Assumptions

In line with model structure and data availability, this paper considers import price of iron ore and import tariff rate of iron ore as influence factors, and tries to obtain variations for relative macro variables. The macro variables chosen in the analysis are: real exchange rate, domestic price and average price of homemade iron ore, gross domestic demand, gross import, gross export, gross investment, gross consumption of domestic market, and household income, among which the variations of proportions of gross investment, gross domestic demand and net export in gross GDP will be stressed, and the change of homemade iron ore price and real exchange rate will be checked in detail.

To construct a theoretical model, some assumptions are given in order to facilitate the following analysis:

(1) Gross domestic output keeps unchanged in short-term. Since the model does not include intermediate inputs, so the gross domestic output can be taken as real gross domestic product.

(2) There exist differences among commodities. Domestic goods and export goods, domestic goods and import goods are all incompletely substituted.

(3) Prices of import and export goods are all determined by international markets. Prices of domestic goods are only determined by supply and demand of domestic market. Domestic technology and preference parameters will not affect prices of international market.

(4) Price is zero homogeneous, so we need to choose criteria for currency exchange rate. In this model, we choose prices of composite consumer goods P_q as criteria for currency exchange rate, that is, P_q is constant.

(5) Production technology, consumer preferences and ownership remain constant between equilibrium schemes and simulation schemes. Although this assumption is very strong, since these factors may change during China's transition process into market economy, they are very difficult to be reflected in the model, thus not considered.

(6) As a vital element of production, technology progress cannot be ignored, since this model

14) Devarajan Shantayanan, Jeffrey D. Lewis and Sherman Robinson, 1990. Policy Lessons from Two-sector Models. *Journal of Policy Modeling*, 12(4): 625-657.

is a comparative static model, technology will not be taken into account.

2.2 Model Structure

Under equilibrium conditions, goods supply and demand are equivalent, which is the assumption of market clearing. This model assumes that iron ore is exclusively produced in the production activities and gross homemade iron ore is for domestic sales and exports. Then, assuming that there is incomplete transformation elasticity between export and domestic sales of gross homemade iron ore, therefore, gross homemade goods is only distributed between export and domestic sales, which can be described by CET (constant elasticity of transformation) function. In the international market, giving international average price, the elasticity between export demand and domestic sale is flexible, if the goods are not for export, then it will be transfered into domestic market.

For import supply, we adopt the Armington assumption that there is incomplete substitution elasticity between import goods and homemade goods, and synthesize them by CES (constant elasticity of substitution) function into composite goods. After that, composite goods are distributed among various domestic demand (household demand, government demand and investment demand). Also, we set international average price of import iron ore as exogenous

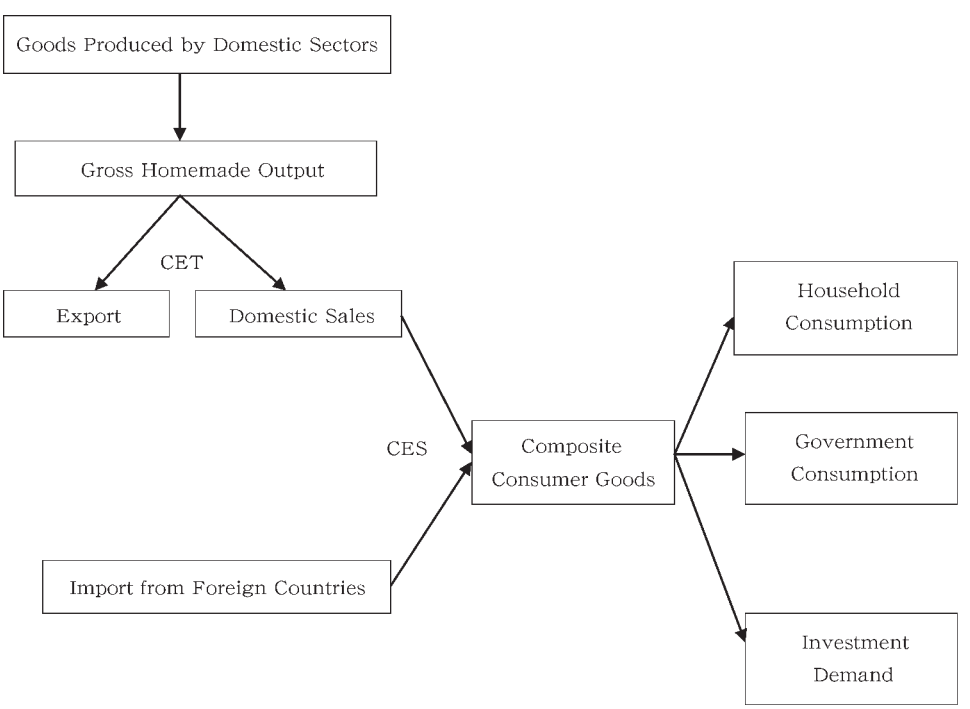

Figure 1　The CGE model's structure

variable, so China become the price recipient. Under this price, the import supply show infinity elasticity and are totally decided by domestic demand and trade equilibrium status. The structure of the CGE model is shown as Figure 1.

In the study, the CGE model equations are composed by four parts: production, consumption, income and demand, and balance relations. The equations involved in the model are as follows (variables and parameters involved in the model are listed in table 1):

Table 1 Variables and parameters of the model

Endogenous Variable	Exogenous Variable	Parameters (CET Function for Domestic Output and CES Function for Composite Consumer Goods)
X_e : Gross Export	X_s : Gross Homemade Output	A_x, B_q : Efficiency Parameters
X_d : Homemade Output Supplied in Domestic Market	P_{we} : Foreign Currency Price of Export	α, β : Distribution Parameters
Q_s : Composite Consumer Goods	P_{wm} : Foreign Currency Price of Import	ϕ, ρ : Substitution Parameters
Q_m : Gross Import	S_f : Net Inflow of Foreign Capital	
D_x : Consumption of Homemade Output in Domestic Market	P_q : Price of Composite Consumer Goods	
Q_d : Gross Domestic Demand	t_m : Customs Tariff Rate of Import	
Y_h : Household Income	t_d : Indirect Tax Rate	
Y_g : Government Revenue	t_h : Direct Tax Rate	
S_g : Government Saving	T_{hg} : Net Transfer Value from Government to Household	
S : Gross Saving	s_h : Household Saving Rate	
Q_i : Gross Investment	T_{hf} : Net Transfer Value from Foreign Countries to Household	
P_e : Domestic Currency Price of Export	Q_g : Government Purchase	
P_m : Domestic Currency Price of Import		
P_x : Price of Homemade Output		
R : Nominal Exchange Rate		
P_d : Homemade Output Price in Domestic Market		
Q_h : Gross Household Demand		

2.2.1 Production

Domestic possible frontier of production:

$$X_s=A_x[\alpha X_e^{\phi}+(1-\alpha)X_d^{\phi}]^{\frac{1}{\phi}} \tag{1}$$

Substitution between export goods and domestic goods:

$$\frac{X_e}{X_d}=\left[\left(\frac{1-\alpha}{\alpha}\right)\frac{P_e}{P_d}\right]^{\frac{1}{\phi-1}} \tag{2}$$

Domestic currency price of export goods:

$$P_e=RP_{we} \tag{3}$$

Nominal values of gross output are the summation of export values and sales values of domestic goods:

$$P_xX_s=P_eX_e+P_dX_d \tag{4}$$

Equation (1) represents the domestic possible frontier of production, which is a constant elasticity of transformation (called CET) function, the elasticity of transformation $\omega=1/(\phi-1)$. Equation (2) is the first order condition of cost minimization for equation (1), which describes the relationship between the production ratios of export goods and domestic goods and the relative price. Equation (3) shows that prices of export goods are decided by international prices of export goods and exchange rate. Equation (4) is a capital flow equation.

2.2.2 Consumption

Gross supply of composite consumer goods:

$$Q_s=B_q[\beta Q_m^{-\rho}+(1-\beta)D_x^{-\rho}]^{-\frac{1}{\rho}} \tag{5}$$

Substitution between import goods and domestic goods:

$$\frac{Q_m}{D_x}=\left[\left(\frac{\beta}{1-\beta}\right)\frac{P_d}{P_m}\right]^{\frac{1}{1+\rho}} \tag{6}$$

Domestic currency price of import goods:

$$P_m=R(1+t_m)P_{wm} \tag{7}$$

Nominal values of composite consumer goods are the summation of import values and sales values of domestic goods:

$$P_dQ_s=P_mX_m+P_dD_x \tag{8}$$

Equation (5) represents the composite consumer goods composed of import goods and domestic goods, which is a constant elasticity of substitution (called CES) function, the elasticity of substitution $\sigma=1/(\rho+1)$. Equation (6) is the first order condition of cost minimization of equation (5), which describes the relations between the consumption proportions of import goods and domestic goods, and the relative price. Equation (7) defines the domestic currency price of import goods. Equation (8) is also a capital flow equation.

2.2.3 Income and Demand

Household Income = Returns of Factors + Government Transfer + Foreign Transfer:

$$Y_h=\left(P_xX_s-\frac{t_d}{1+t_d}P_dX_d\right)+T_{hg}+RT_{hf} \tag{9}$$

Household Consumption = Remaining income after tax and savings:

$$Q_h=\frac{(1-s_h)(1-t_h)\,Y_h}{P_q} \tag{10}$$

Gross Domestic Demand = Household Consumption + Government Purchases + Investment:

$$Q_d=Q_h+Q_g+Q_i \tag{11}$$

Government Revenues = Customs Tariff + Indirect Tax + Income Tax:

$$Y_g=t_mRP_{wm}Q_m+t_dP_dX_d/(1+t_d)+t_hY_h \tag{12}$$

Gross Savings = Household Savings + Government Savings + Net Inflow of Foreign Capitals:

$$S=s_h(1-t_h)\,Y_h+S_g+RS_f \tag{13}$$

Equation (9)-(13) describe income and demand of the economy. Equation (9) is the household income equation, in which the returns of factors equal that gross domestic product minus indirect taxes. Household consumption equals that household income minus household savings, where there is a exogenous constant savings rate s_h. Government revenue are mainly from taxes, where government purchase Q_g is assumed to be exogenously constant. The gross savings of the whole economy is the summation of household savings, government savings and foreign savings.

2.2.4 Balance

Supply and demand balance of domestic goods:

$$X_d=D_x \tag{14}$$

Supply and demand balance of composite goods:

$$Q_s=Q_d \tag{15}$$

International balance of payments:

$$P_{wm}Q_m-P_{we}X_e-T_{hf}=S_f \tag{16}$$

Balance of government revenues and expenditures:

$$S_g=Y_g-P_qQ_g-T_{hg} \tag{17}$$

Balance of investment and savings:

$$P_qQ_i=S \tag{18}$$

Equation (14)-(18) give equilibrium relations of the CGE model of iron ore resource imports. These five balance equations are not independent, because they must satisfy the Walras Law. Thus, this CGE model is consisted of 17 independent equations.

2.3 Data Problem

It is necessary to establish China's Social Accounting Matrix (called SAM) to provide data for the CGE model. This paper makes SAM based on the latest Input-Output (called IO) table 2002 which was constructed by National Bureau of Statistics of China. IO table 2002 could reflect current economic situations well since it absorbs economic census information of 2004. The data of the paper are mainly from 17 sectors' input-output tables of 2002 in *China Statistics Yearbook 2006*, *China Finance Statistics Yearbook 2003*, *China Customs Statistics Yearbook 2002*, and *International Balance of Payment 2002*. Based on these, I use the software GAMS to adjust and balance the IO table and tries to build China's macro SAM table of 2002 shown by table 2.

2.4 Parameter Estimation and Model Calibration

In the model, by setting all accounts' prices of the baseline equilibrium data to 1, the value data of SAM can be viewed as the number data. Therefore, the model's simulation results of the baseline data show that when all the prices are equal to 1, every market will reach to the equilibrium state.

2.4.1 Parameter Estimation

There have been many studies on the parameter estimation of CET function and CES function. The methods used are generally the same: firstly, make logarithm on both sides of the function, and then make Taylor expansion at the point that ϕ equals 0 and ρ equals 0 respectively. Then select the linear parts about ϕ and ρ, take every term of expansion equation as independent variables, at last, estimate every parameter using time-series data and the OLS (Optimization Least Square) method. Here, to avoid repeated work, the paper refers to Whalley's (1985)[15] study method and Zhai's (1997)[16] estimation results to obtain that: $\rho=-5.03$, $\phi=0.51$. Substitution parameter ϕ is the elasticity of substitution between domestic demand and export demand of homemade iron ore. Since its value is less than 1, which is not accordance with the requirements of equations and econometric theory, sensitivity analysis will be used to obtain its real value in the following section.

2.4.2 Model Calibration and Initialization

(1) The calibration of parameters

The calibration process is to retain the substitution parameter ρ estimated by the OLS, set ϕ

15) Whalley J. and B. Yeung, 1984. External Sector Closing Rules in Applied General Equilibrium Models. Journal of International Economics, 16: 123-138.

16) Zhai, F., S. Li and S. Feng, 1997. One of the Computable General Equilibrium Model of China's Economy. *Journal of Quantitative and Technological Economics (China)*, 3: 38-44.

Table 2 Macro SAM balance sheet of China in 2002 Unit: 100 Million Yuan

	Activity	Commodity	Labor	Capital	Household	Enterprise	Government	Capital Account	ROW	Total
Activity		296661.993								296661.99
Commodity	192194.013				48881.692		13916.221	39579	30238.018	324808.94
Labor	62524.001								-22.994	62501.00
Capital	24814.007									24814.00
Household			62501.006	1180.113		5507.027	3438.221		1081.018	73707.39
Enterprise				23598.933			1247.155		-1214.048	23632.04
Government	17129.973	703.960		34.960	5259.960	3082.987			-6.022	26205.82
Capital Account					19565.734	15042.027	7604.221		-2632.982	39579.00
ROW		27442.991								27442.99
Total	296661.99	324808.94	62501.00	24814.00	73707.39	23632.04	26205.82	39579.00	27442.99	

Data Source: Computation Results of the GAMS Program based on IO table 2002 of National Bureau of Statistics of China.
ROW: The other districts of the world.

an assumed value, and take them with the baseline data into the CET and CES functions and also equations of their first order conditions, in order to estimate the efficiency parameters A_X and B_q and the distribution parameters α and β. The calibration equations are as follows:

$$A_x=X_s/[\alpha X_e^{\phi}+(1+\alpha)X_d^{\phi}]^{\frac{1}{\phi}} \tag{19}$$

$$\alpha=1/\left[\frac{P_d}{P_e}\left(\frac{X_e}{X_d}\right)^{\phi-1}+1\right] \tag{20}$$

$$B_q=Q_s/[\beta Q_m^{-\rho}+(1-\beta)D_x^{-\rho}]^{-\frac{1}{\rho}} \tag{21}$$

$$\beta=1/\left[\frac{P_d}{P_m}\left(\frac{X_d}{Q_m}\right)^{1+\rho}+1\right] \tag{22}$$

Based on the equations above, here we set $\rho=-5.03$. In order to fix value of ϕ, we need to make sensitivity analysis. We make programs in the econometric software EViews 6.0, try to assign different values to parameter ϕ for many times, at last, two better values are selected: $\phi=$ 1.2 and 8.1. After calculations, calibration values for every parameter under different conditions are obtained and shown in table 3:

Table 3　Calibration values of parameters

ρ	ϕ	A_x	B_q	α	β
-5.03	1.2	2.0311	7.0963	0.6122	0.9999
-5.03	8.1	7.3126	7.0963	1.0000	0.9999

(2)　The calibration of exogenous variables

In this section, we consider China's SAM balance sheet of 2002 as the baseline data to make calibration for exogenous variables. Since SAM reflects the gross value of China's macro-economy in 2002, we take its data into the CGE model and can derive values for every exogenous variable and parameter.

First of all, we assign values to variables, because all prices are assumed to 1 previously, we can derive international market prices of import goods and export goods.

Furthermore, we can calculate every tax rate and saving rate using various taxes and gross savings derived from SAM table. Here, sam is defined as social accounting matrix, and sam (a, b) is represented as the data of a row and b column in SAM table. The calibration process is given as follows:

$R=1$　　$P_x=1$　　$P_e=1$　　$P_d=1$　　$P_m=1$　　$P_q=1$

$X_d=sam\,(1,\ 2)$　　$X_x=sam\,(1,\ 10)$　　$X_e=sam\,(2,\ 9)$

$Q_h=sam\,(2,\ 5)$　　$Q_g=sam\,(2,\ 7)$　　$Q_i=sam\,(2,\ 8)$

$T_{hg}=sam\,(5,\ 7)$　　$T_{hf}=sam\,(5,\ 9)/R$　　$Y_h=sam\,(5,\ 10)$

Indirect tax $ind\_tax=sam\,(7,\ 1)$

Customs import $tariff = sam(7, 2)$

Income tax $hh\_tax = sam(7, 5)$ $Y_g = sam(7, 10)$

Household saving $sav\_hh = sam(8, 5)$

$S_g = sam(8, 7)$ $S_f = sam(8, 9)/R$

$S = sam(8, 10)$ $Q_m = sam(7, 2) + sam(9, 2)$ $Q_s = sam(10, 2)$

$t_d = ind\_tax/(P_d X_d - ind\_tax)$ $t_m = tariff/(P_m Q_m - tariff)$ $P_{we} = P_e/R$

$P_{wm} = P_m/R(1 + t_m)$ $t_h = hh\_tax/Y_h$ $s_h = sav\_hh/((1 - t_h) Y_h)$

After evaluations above, we make programs in EViews 6.0 to calculate calibration values for every exogenous variable. The results are listed in table 4:

Table 4 Calibration values of exogenous variables

Exogenous Variable	Estimation Value	Exogenous Variable	Estimation Value	Exogenous Variable	Estimation Value
P_q	1	S_f	-2632.98	t_m	0.0257
P_{wm}	0.9750	s_h	0.0711	T_{hg}	3438.2
P_{we}	1	t_d	0.0613	T_{hf}	1081.18
Q_g	13916.22	t_h	0.0187	X_s	296662

3. Simulation Analysis Based on the CGE Model

3.1 Simulation Schemes

Firstly, we make use of the CGE model to simulate shocks of the fluctuations of average C.I.F. (cost, insurance and freight) of import iron ore on China's macroeconomic indicators respectively, which is actually the sensitivity analysis of prices. Secondly, we make simulations of the impact of reduction of import tariff rates of iron ore on macroeconomic indicators, indicating the effects of different tax policies, which is actually the sensitivity analysis of tariff rates. Among them, we include sensitivity analysis of ϕ for every simulation. The value of ϕ has reciprocal relation with ω, which is the transformation elasticity between domestic demand and export demand of homemade iron ore. It reflects the substitution intensity between export and domestic sales of homemade iron ore. If ϕ is higher, the substitution is smaller; vice versa.

(1) Scheme 1: According to average C.I.F. of import iron ore and its increase from 2002 to 2008, the calculation of average C.I.F. is 67.62 dollars/ton, the annual increase 37.52%. Based on this, under the fixed exchange rate, we simulate variation of macro-economic indicators when average C.I.F. of import iron ore rises by 10%, 20%, 37.52% and 60% respectively.

(2) Scheme 2: To avoid adverse impact of rising import prices of iron ore, China plans to reduce import tariff rates of iron ore by 30%, 80%, 130% and 180% respectively. Under the fixed

exchange rate, these four policies are simulated to measure the effect on macro-economic indicators.

3.2 Simulation Results

3.2.1 Simulation results of different increases of average C.I.F. of import iron ore resources

(1) Under the fixed exchange rate, China's average C.I.F. of import iron ore rises by 10%, 20%, 37.5% and 60% separately. The simulation results are shown in table 5 and table 6:

Table 5 Sensitivity analysis of C.I.F. of import iron ore ($\phi=1.2$)

Variable	Basic Solution	Price Increases 10%			Price Increases 20%			Price Increases 37.5%			Price Increases 60%		
		Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)
Nominal Exchange Rate (R)	1.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000
Real Exchange Rate (R/P_d)	1.0000	1.0103	0.0103	1.0300	1.0219	0.0219	2.1900	1.0434	0.0434	4.3400	1.0732	0.0732	7.3200
Gross Domestic Demand (Q_d)	295892.7	293256.9	-2635.8000	-0.8908	290760.6	-5132.1000	-1.7344	286390.6	-9502.1000	-3.2113	280818.8	-15073.9000	-5.0944
Average Price of Homemade Iron Ore (P_x)	1.0000	0.9914	-0.0086	-0.8600	0.9827	-0.0173	-1.7300	0.9675	-0.0325	-3.2500	0.9482	-0.0518	-5.1800
Domestic Price of Homemade Iron Ore (P_d)	1.0000	0.9898	-0.0102	-1.0200	0.9786	-0.0214	-2.1400	0.9584	-0.0416	-4.1600	0.9318	-0.0682	-6.8200
Gross Import (Q_m)	28146.95	26057.81	-2089.1400	-7.4223	26468.1	-1678.8500	-5.9646	27057.37	-1089.5800	-3.8710	27616.74	-530.2100	-1.8837
Gross Export (X_e)	27831.11	29498.67	1667.5600	5.9917	32519.32	4688.2100	16.8452	37830.64	9999.5300	35.9293	44633.64	16802.5300	60.3732
Gross Investment (Q_i)	23268.91	24189.44	920.5300	3.9561	23709.04	440.1300	1.8915	22878.81	-390.1000	-1.6765	21838.75	-1430.1600	-6.1462
Gross Consumption (D_x)	268830.9	267163.3	-1667.6000	-0.6203	264142.7	-4688.2000	-1.7439	258831.3	-9999.6000	-3.7197	252028.4	-16802.5000	-6.2502
Household Income (Y_h)	282977.7	279915.2	-3062.5000	-1.0822	277703.6	-5274.1000	-1.8638	273820.3	-9157.4000	-3.2361	268848.7	-14129.0000	-4.9930

Table 6 Sensitivity analysis of C.I.F. of import iron ore (ϕ=8.1)

Variable	Basic Solution	Price Increases 10%			Price Increases 20%			Price Increases 37.5%			Price Increases 60%		
		Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)
Nominal Exchange Rate (R)	1.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000
Real Exchange Rate (R/P_d)	1.0000	0.9645	-0.0355	-3.5500	0.9397	-0.0603	-6.0300	0.9312	-0.0688	-6.8800	0.9301	-0.0699	-6.9900
Gross Domestic Demand (Q_d)	295892.7	294232.3	-1660.4000	-0.5611	296004.6	111.9000	0.0378	300281.9	4389.2000	1.4834	304702.6	8809.9000	2.9774
Average Price of Homemade Iron Ore (P_x)	1.0000	0.9935	-0.0065	-0.6500	0.9984	-0.0016	-0.1600	1.0123	0.0123	1.2300	1.0271	0.0271	2.7100
Domestic Price of Homemade Iron Ore (P_d)	1.0000	1.0368	0.0368	3.6800	1.0642	0.0642	6.4200	1.0739	0.0739	7.3900	1.0752	0.0752	7.5200
Gross Import (Q_m)	28146.95	22332.58	-5814.3700	-20.6572	17562.23	-10584.7200	-37.6052	11899.48	-16247.4700	-57.7237	7537.67	-20609.2800	-73.2203
Gross Export (X_e)	27831.11	25503.41	-2327.7000	-8.3637	22099.55	-5731.5600	-20.5941	17506.86	-10324.2500	-37.0961	13310.61	-14520.5000	-52.1736
Gross Investment (Q_i)	23268.91	25931.33	2662.4200	11.4420	27302.69	4033.7800	17.3355	28364.87	5095.9600	21.9003	29067.34	5798.4300	24.9192
Gross Consumption (D_x)	268830.9	271158.6	2327.7000	0.8659	274562.4	5731.5000	2.1320	279155.1	10324.2000	3.8404	283351.4	14520.5000	5.4014
Household Income (Y_h)	282977.7	279074.3	-3903.4000	-1.3794	279514.2	-3463.5000	-1.2239	283041.3	63.6000	0.0225	287120.5	4142.8000	1.4640

(2) In the case that ϕ equals 1.2 and 8.1, we describe the relations by figures among increase of C.I.F. of import iron ore, gross investment, gross consumption, gross export, gross import, household income, gross domestic demand, and variation of domestic and average price of homemade iron ore (Here, x1, x2, x3, and x4 represent that C.I.F. of import iron ore rises by 10%, 20%, 37.5% and 60% separately).

① When $\phi=1.2$, the results are shown as figures below:

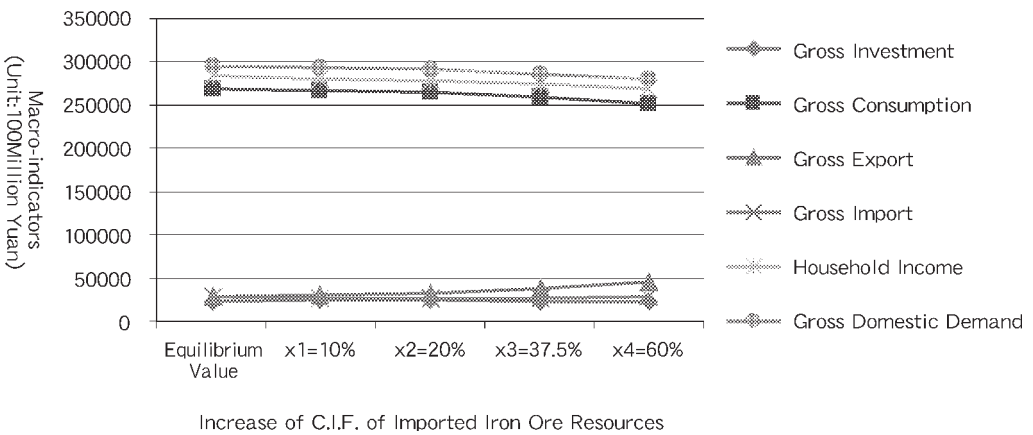

Figure 2 Trend of macro-indicators when C.I.F. of imported iron ore increases ($\phi=1.2$)

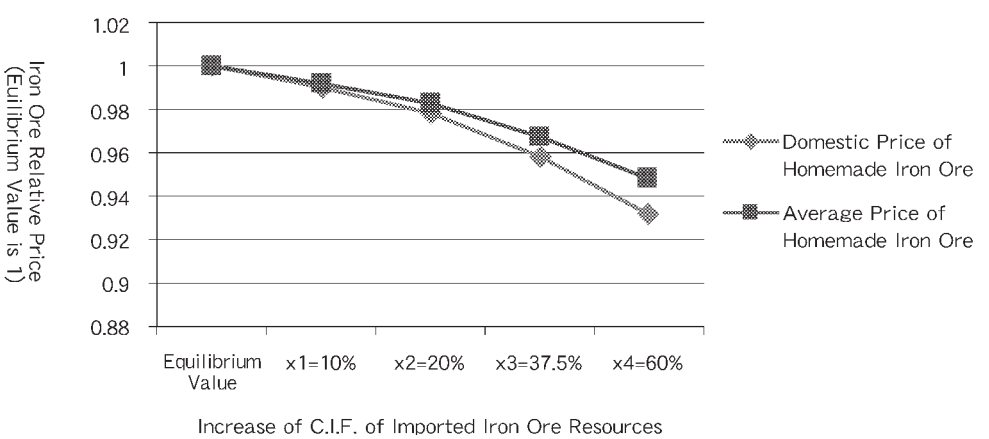

Figure 3 Trend of homemade iron ore price when C.I.F. of imported iron ore increases ($\phi=1.2$)

As the figure shows, when $\phi=1.2$, if the rise of C.I.F. of import iron ore is gradually increasing, gross domestic demand, gross import, gross investment, gross consumption and household income decline, gross export rises, domestic and average price of homemade iron ore fall down, and

average price fall less than domestic price. This indicates that if the substitution between export and domestic sales of homemade iron ore is relatively higher, the adverse impact of rising international iron ore price on macro-economy is very serious. Induced by high international price, exports of homemade iron ore rise quickly, and domestic sales fall sharply, so domestic supply becomes relatively deficit, which restrains consumption and investment. Meanwhile, higher import price suppress import demand which will bring adverse impact on macro-economy.

② When $\phi=8.1$, the results are shown as figures below:

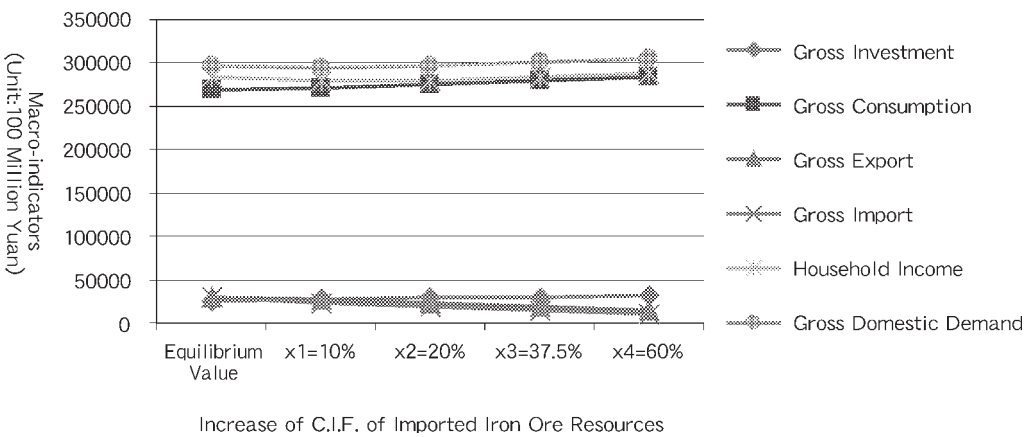

Figure 4　Trend of macro-indicators when C.I.F. of imported iron ore increases ($\phi=8.1$)

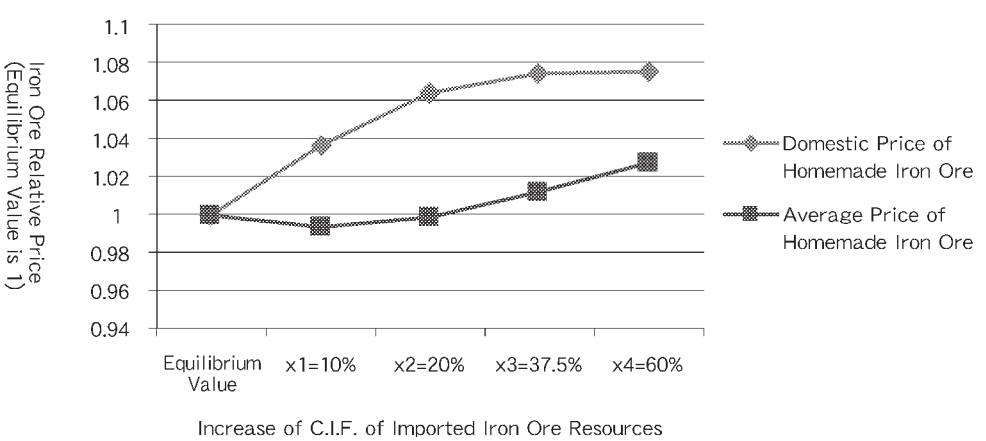

Figure 5　Trend of homemade iron ore price when C.I.F. of imported iron ore increases ($\phi=8.1$)

The figure shows, when $\phi=8.1$, if the rise of C.I.F. of iron ore is increasing, gross domestic demand, gross investment, gross consumption and household income keep stable generally or have minor increase, gross import and export decline sharply and gross import decrease more than gross export. This indicates that when the substitution between exports and domestic sales of homemade iron ore is lower, the influence of rising international price on macro-economy is small, and mainly results in sharp decline of gross export and import.

At the same time, if the rise of C.I.F. is increasing, domestic and average price of homemade iron ore both rise and that domestic price rise higher than average price, which means that when the substitution between export and domestic sales of homemade iron ore is lower, the rise of international price is easy to induce rise of domestic price. This is because that reduction of iron ore export has little impact on rise of domestic sales, so there are only very small shocks on domestic demand and supply. This also indicates that domestic iron ore price in China are mainly controlled by international market.

3.2.2 Simulation results of different deceases of import tariff rate of iron ore resources

(1) Under the fixed exchange rate, China's import tariff rates of iron ore are decreased by 30%, 80%, 130% and 180% respectively. The simulation results are denoted in table 7 and table 8:

Table 7　Sensitivity analysis of import tariff rate of iron ore (ϕ=1.2)

Variable	Basic Solution	Tariff Rate Decreases 30%			Tariff Rate Decreases 80%			Tariff Rate Decreases 130%			Tariff Rate Decreases 180%		
		Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)
Nominal Exchange Rate (R)	1.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000
Real Exchange Rate (R/P_d)	1.0000	0.9987	-0.0013	-0.1300	0.9975	-0.0025	-0.2500	0.9942	-0.0058	-0.5800	0.9927	-0.0073	-0.7300
Gross Domestic Demand (Q_d)	295892.70	295747.8	-144.9000	-0.0490	295747.6	-145.1000	-0.0490	295753.1	-139.6000	-0.0472	295758.9	-133.8000	-0.0452
Average Price of Homemade Iron Ore (P_x)	1.0000	1.0006	0.0006	0.0600	1.0017	0.0017	0.1700	1.0049	0.0049	0.4900	1.0064	0.0064	0.6400
Domestic Price of Homemade Iron Ore (P_d)	1.0000	1.0013	0.0013	0.1300	1.0025	0.0025	0.2500	1.0058	0.0058	0.5800	1.0074	0.0074	0.7400
Gross Import (Q_m)	28146.95	25537.97	-2608.9800	-9.2691	25460.88	-2686.0700	-9.5430	25224.89	-2922.0600	-10.3814	25112.24	-3034.7100	-10.7817
Gross Export (X_e)	27831.11	26451.22	-1379.8900	-4.9581	26376.06	-1455.0500	-5.2281	26145.98	-1685.1300	-6.0548	26036.14	-1794.9700	-6.4495
Gross Investment (Q_i)	23268.91	24510.6	1241.6900	5.3363	24239.94	971.0300	4.1731	23437.74	168.8300	0.7256	23068.65	-200.2600	-0.8606
Gross Consumption (D_x)	268830.90	270210.8	1379.9000	0.5133	270285.9	1455.0000	0.5412	270516	1685.1000	0.6268	270625.8	1794.9000	0.6677
Household Income (Y_h)	282977.70	282295.6	-682.1000	-0.2410	282592.2	-385.5000	-0.1362	283478.3	500.6000	0.1769	283889.6	911.9000	0.3223

Table 8 Sensitivity analysis of import tariff rate of iron ore (ϕ=8.1)

Variable	Basic Solution	Tariff Rate Decreases 30%			Tariff Rate Decreases 80%			Tariff Rate Decreases 130%			Tariff Rate Decreases 180%		
		Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)	Simulation Solution	Variation Value	Variation Ratio (%)
Nominal Exchange Rate (R)	1.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000
Real Exchange Rate (R/P_d)	1.0000	1.1292	0.1292	12.9200	1.0222	0.0222	2.2200	1.0794	0.0794	7.9400	1.0846	0.0846	8.4600
Gross Domestic Demand (Q_d)	295892.7	298858.8	2966.1000	1.0024	295940	47.3000	0.0160	297262.4	1369.7000	0.4629	297414.2	1521.5000	0.5142
Average Price of Homemade Iron Ore (P_x)	1.0000	1.0145	0.0145	1.4500	1.0035	0.0035	0.3500	1.0174	0.0174	1.7400	1.0219	0.0219	2.1900
Domestic Price of Homemade Iron Ore (P_d)	1.0000	0.8856	-0.1144	-11.4400	0.9783	-0.0217	-2.1700	0.9264	-0.0736	-7.3600	0.9220	-0.0780	-7.8000
Gross Import (Q_m)	28146.95	31031.3	2884.3500	10.2475	26953.26	-1193.6900	-4.2409	29445.88	1298.9300	4.6148	29628.12	1481.1700	5.2623
Gross Export (X_e)	27831.11	31807.17	3976.0600	14.2864	27831.11	0.0000	0.0000	30261.39	2430.2800	8.7322	30439.08	2607.9700	9.3707
Gross Investment (Q_i)	23268.91	20891.44	-2377.4700	-10.2174	23268.91	0.0000	0.0000	19419.15	-3849.7600	-16.5447	18203.16	-5065.7500	-21.7705
Gross Consumption (D_x)	268830.9	264654.8	-4176.1000	-1.5534	268830.9	0.0000	0.0000	266400.6	-2430.3000	-0.9040	266222.9	-2608.0000	-0.9701
Household Income (Y_h)	282977.7	289678.9	6701.2000	2.3681	283868.6	890.9000	0.3148	289542.8	6565.1000	2.3200	291043.3	8065.6000	2.8503

(2) In the case that ϕ takes the value 1.2 and 8.1, we draw the relations among decrease of import tariff rate of iron ore, gross investment, gross consumption, gross export, gross import, household income, gross domestic demand, and variation of domestic and average price of homemade iron ore (Here, y1, y2, y3 and y4 represent that import tariff rate is decreased by 30%, 80%, 130% and 180% separately).

① When $\phi=1.2$, the results are shown as below:

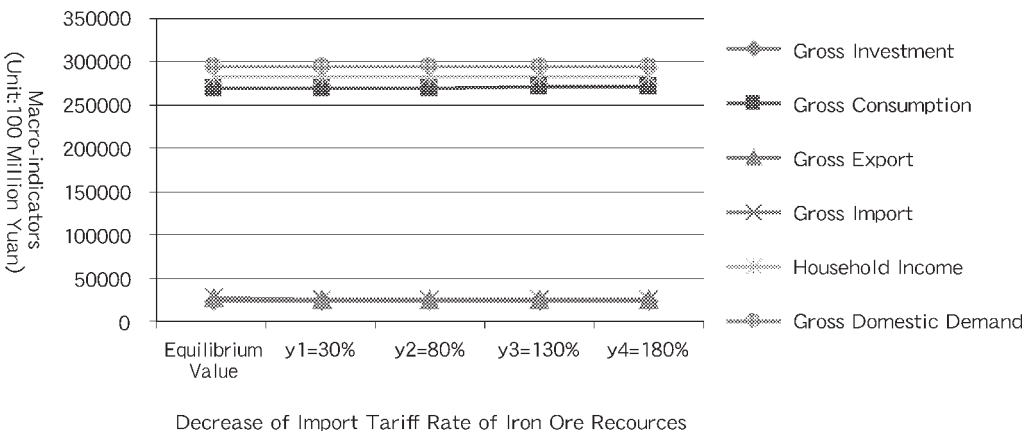

Figure 6 Trend of macro-indicators when import tariff rate of iron ore decreases ($\phi=1.2$)

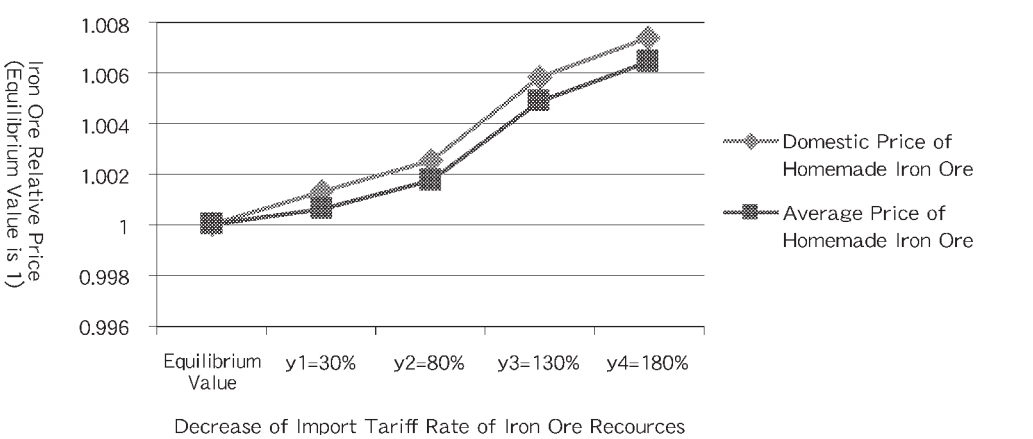

Figure 7 Trend of homemade iron ore price when import tariff rate of iron ore decreases ($\phi=1.2$)

As the figure shows, at ϕ=1.2, the influence of reduction of import tariff rates on gross investment, gross consumption and gross domestic demand is not obvious. Household income shows a small increase, while gross import and gross export have slight drops. At the same time, domestic and average price of homemade iron ore both rise and that domestic price rise higher than average price.

② When ϕ= 8.1, the results are shown as below:

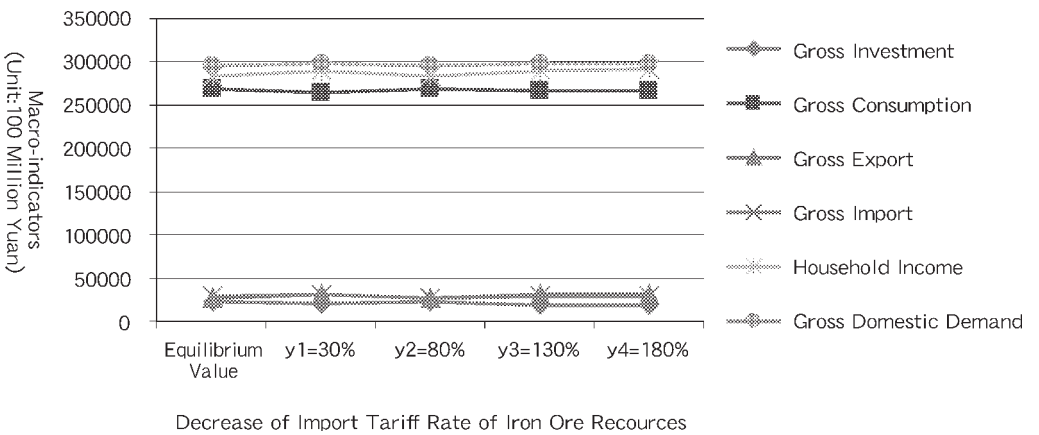

Figure 8 Trend of macro-indicators when import tariff rate of iron ore decreases (ϕ=8.1)

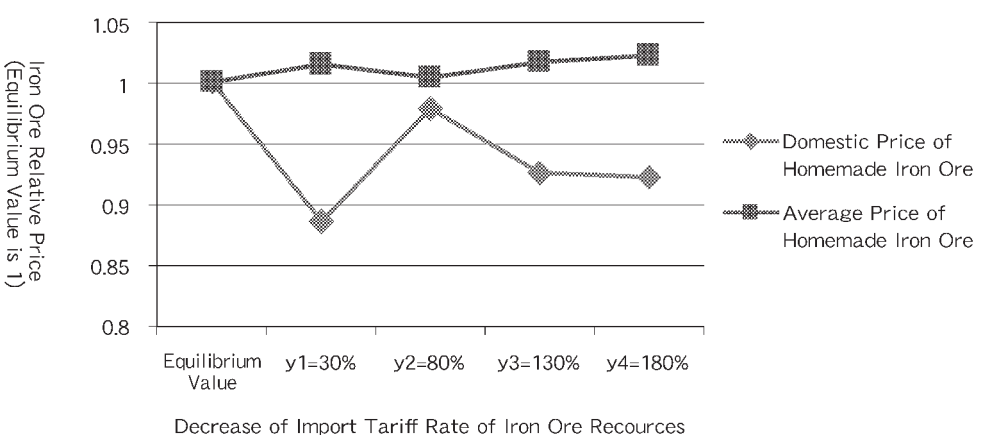

Figure 9 Trend of homemade iron ore price when import tariff rate of iron ore decreases (ϕ=8.1)

The figure indicates that when ϕ=8.1, the influence of reduction of import tariff rate on gross investment, gross consumption and gross domestic demand is very limited. The household show a slight increase in income, while gross import and export have obvious increase. Meanwhile,

domestic price of homemade iron ore drops in general, but it cannot change the trend of slight rise of the average price.

4 . Conclusion and Recommendation

4.1 Conclusion

Based on the baseline data of 2002 and the variations from 2002 to 2008, this paper makes use of the CGE model to analyze the impact of fluctuations of iron ore resource imports on China's macro-economy. The main results can be summarized as followings:

(1) The value of ϕ is a significant factor to determine the direction and extent of macro-economic changes. It reflects the substitution intensity between export and domestic sales of homemade iron ore. If ϕ is higher, the substitution is smaller; vice versa. Totally speaking, when $\phi=8.1$, that is the substitution between export and domestic sales of homemade iron ore is lower, the simulation results can tally with the reality properly. At this time, the influence of fluctuation of C.I.F on macro-economy is small, which shows that the real effect of the policy is satisfied.

(2) The impact of the rising C.I.F. on macro-economy is significant. It is easy to find that the rise of C.I.F. take effect through the indicators of amount and structure on economy from previous sensitivity analysis.

On one hand, we can see that gross import and export are significantly influenced, thereinto, gross import show a sharp decline trend. However, the variations of gross investment, gross consumption, gross domestic demand and household income have close connection with value of ϕ. When ϕ takes different values, every indicator has opposite direction of variation. On the other hand, rising C.I.F. has influenced on economic structure through variations of proportions of gross investment, gross consumption and gross export and import in gross GDP. When ϕ takes the same value, the rise of C.I.F. makes gross investment and consumption fluctuate with the same direction, but variation of net export is opposite, thereof, gross GDP can keep in an equilibrium status. So we can conclude that an economic system can keep stable with exogenous shocks on condition that the inner economic structure should be changed.

(3) It takes different effect for tariff adjustment policies to choose different values of ϕ from the simulation results of import tariff rate.

Firstly, no matter what value ϕ takes, with the decline of tariff rates, household income always shows a rising trend and that the higher the tariff rate decline, the more the income increase. Nevertheless, the influence on gross investment, gross consumption and gross domestic demand is not obvious, indicating that tariff policy can only serve to ease the economic shocks but cannot fundamentally smooth economic hurt. Moreover, tax reduction plays a significant role in the

international trade. When ϕ takes a smaller value ($\phi=1.2$), after tax rates reduced, gross import and export will be decreased; when ϕ value becomes larger ($\phi=8.1$), gross import and export will rise under a lower tariff rate. Generally speaking, decrease of import tariff rates will increase the volume of import and export, but if the substitution between export and domestic sales of homemade iron ore is stronger ($\phi=1.2$), domestic producers are willing to transfer more goods into domestic market and reduce the exports, thereof, domestic demand can be satisfied, and foreign iron ore imports will be decreased.

4.2 Recommendation

According to previous simulations and analysis, we can conclude that, the weaker the substitution between export and domestic sales of homemade iron ore is (the bigger ϕ value takes), the smaller the shocks of import price of iron ore is, therefore, government policies will become more effective to smooth the shocks. Based on this, in order to solve the problems existed in China's iron ore import, I make some recommendations for China to cope with the adverse economic impact and reduce the losses as much as possible.

4.2.1 Stabilize the import prices of iron ore resources in many ways

(1) China should pursuit the pricing power of international price of iron ore. Firstly, it is rational for the government and guild to coordinate with domestic enterprises to maintain unity in the international price negotiations. After acceptable and consistent price ranges and import volumes decided, enterprises representatives should start negotiations with international iron ore exporters. Meanwhile, China's steel enterprises should assign as many long-term contracts of iron ore imports as possible to prevent fluctuations and traps of spot iron ore import[17].

(2) In order to regulate import behaviors, customs should enhance declaration procedures, low volume limit imports and also uniform import market. At the same time, it is quite necessary for China's mining administration to make and implement license administration of automatic import and standards for import qualifications to reduce the risk of bull trade and panic purchasing at high prices.

4.2.2 Enhance tax policy in corporation with other policy instruments

(1) Reducing import tariff rate is important for the government to ease import price shocks, but that does not mean tariff rate should be reduced without any limitations. It will bring serious shocks for excessive tax reduction on domestic small enterprises and industries. Inappropriate tax rate can inhibit investment and consumption. Therefore, it is necessary to fix and implement

17) Chen, X., 2007. Strategies and Distributions of China's Imports of Iron Ore Resources. *Metallurgy Management (China)*, 1: 33-34.

new rational tariff rates to reduce losses caused by rising import prices and protect interests of domestic consumers.

(2) The role of tariff reduction is limited in smoothing price shocks, so the government should adopt more measures in corporation with tax policy. Under current situations, it is necessary for the government to make and implement long-term programs of strategic alliances and foreign direct investment of domestic steel companies and industries. The companies should form strategic alliances as much as possible, enhance friendship and cooperation with each other to reduce purchase costs of raw materials and other unnecessary costs, and invest more on foreign mining and quarrying to resist the international market risks together.

4.2.3 Promote sustainable development of resource-saving

The essence of the issue of iron ore import lies in the iron ore resources shortage in China. Therefore, we must go the way of sustainable development of resource-saving. On one hand, it is necessary for us to rectify and close small steel enterprises and industries with huge consumption of iron ore to save existing iron resources and reduce unnecessary waste. On the other hand, we should investment more on technology and innovation projects to accelerate development of alternative products in order to supplement the shortage of domestic iron ore resources.

References

Beghin J., S. Dessus, D. Roland-Holst and D. Van der Mennsbrugghe, 1997. The Trade and Environment Nexus in Mexican Agriculture: A General Equilibrium Analysis. *Agricultural Economics,* 17 (2-3): 115-131.

Connolly, M., 2003. The Dual Nature of Trade: Measuring Its Import on Limitation and Growth. *Journal of Development Economics*, 72.

Gong, Y., 1997. Several Issues on the Computable General Equilibrium Model. *Journal of Quantitative and Technological Economics (China)*, 8: 21-28.

Hu, Z., W. Cai and H. Chen, 2008. The CGE Study on the Impact of Energy Prices on Energy Intensity and Economic Growth. *Financial Theory and Practice*, 152: 91-95.

Jin, X. and Z. Xu, 2008. International Trade and the Development of China's Manufacturing: Based on the Simulation Analysis of Computable General Equilibrium (CGE). *Modern Economics and Management (China)*, 4: 55-59.

Kirk and William, 2004. China's Emergence as the World's Leading Iron-ore-consuming Country. *Minerals and Energy*, 19 (2): 16-27.

Labson B. Stephen, 1997. Changing Patterns of Trade in the World Iron Ore and Steel Market: An Econometric Analysis. *Journal of Policy Modeling*, 19 (3): 237-251.

Ma, K., 2008. The Game of China's Iron Ore Mining in the International Prices. *Innovation Newspaper*, 4: 117.

Min, F., 2005. The Analysis of the Impact of Rising Prices of Imported Iron Ore on Steel and Related Industries. *China Trade Guide (China)*, 7: 11-12.

Robinson S., S. Subramanian and J. Geoghegan, 1993. A Regional Environmental Computable General Equilibrium Model of the Los Angeles Basin. Department of Agricultural and Resource Economics, University of California, Berkeley.

Schmitz and James, 2005. What Determines Productivity ? Lessons from the Dramatic Recovery of the U.S. and Canadian Iron Ore Industries Following Their Early 1980s Crisis. *Federal Reserve Bank of Minneapolis Research Department Staff Report 286*.

Vielle, M. and L. Viguier, 2007. On the Climate Change Effects of High Oil Prices. *Energy Policy*, 35 (2): 844–849.

Wang, D., 2006. The Empirical Research on the Effect of Labor Substitution of Energy Tax: Based on Computation of CGE Model of Shanghai's Air Pollution in 2002. *Journal of Finance and Economics (China)*, 2: 98-105.

Wang, H. and M. Ouyang, 2007. Transition Strategy of the Transportation Energy and Power-train in China. *Energy Policy*, 35 (4): 2313-2319.

Wei, W., 2006. The Evaluation of the Impact of RMB Appreciation on Macro-economy. *Economic Research Journal (China)*, 4: 47-57.

Whalley, J. and B. Yeung, 1984. External Sector Closing Rules in Applied General Equilibrium Models. *Journal of International Economics*, 16: 123-138.

Zhai, F., S. Li and S. Feng, 1997. One of the Computable General Equilibrium Model of China's Economy. *Journal of Quantitative and Technological Economics (China)*, 3: 38-44.